# Response of bean to applications of hydrophobic mineral particles

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Tworkoski, T. J., Glenn, D. M. and Puterka, G. J. 2002. **Response of bean to applications of hydrophobic mineral particles.** Can. J. Plant Sci. **82**: 217–219. Foliar applications of hydrophobic mineral particles can protect plants from some insects, but plant response to particle applications is not known. Bean (*Phaseolus vulgaris* L.) plants were grown for 8 wk in a greenhouse and the shoots were sprayed weekly with small-diameter hydrophobic mineral particles. Photosynthesis was similar in particle-treated and control bean plants over a photosynthetic photon flux (PPF) range from 0 to 1548 μmol $m^{-2}$ $s^{-1}$. The shoot-to-root dry weight ratio was 56% greater and pod weight was 20% lower in particle-treated plants than control plants, suggesting that particle films may alter dry weight partitioning of plants. In bean, particle residues of 2.71 mg $cm^{-2}$ leaf area altered plant development without affecting photosynthesis.

**Key words**: *Phaseolus vulgaris*, crop protection, photosynthesis, dry weight distribution, kaolin

Tworkoski, T. J., Glenn, D. M. et Puterka, G. J. 2002. **Réaction du haricot à l'application de particules minérales hydrophobes**. Can. J. Plant Sci. **82**: 217–219. L'application de particules minérales hydrophobes aux feuilles peut protéger les végétaux contre certains insectes, mais on ignore comment réagira la plante. Les auteurs ont cultivé des plants de haricot (*Phaseolus vulgaris* L.) en serre pendant huit semaines en les arrosant chaque semaine de petites particules minérales hydrophobes. La photosynthèse était similaire chez les plants témoins et les plants traités pour un flux de photons allant de 0 à 1 548 μmol $m^{-2}$ $s^{-1}$. Le ratio entre le poids sec des pousses et des racines avait augmenté de 56 % et les gousses étaient 20 % plus légères chez les plants traités, comparativement aux plants témoins, signe que les particules pourraient modifier la répartition du poids sec chez la plante. Des résidus de particules de 2,71 mg $cm^{-2}$ de surface foliaire affectent le développement du haricot sans modifier la photosynthèse.

**Mots clés**: Phaseolus vulgaris, phytoprotection, photosynthèse, répartition du poids sec, kaolin

Alternatives to synthetic chemical pesticides are needed to ameliorate restrictions of pesticide use that are likely to result from legislation such as the Food Quality Protection Act in the United States of America. Mineral particles have been studied for insecticide action (Alexander et al. 1944; David and Gardiner 1950) and for effects on fungal infection (Farmer 1993). New forms of hydrophobic mineral particles were discovered to deter feeding of fruit-damaging insects such as pear psylla (*Cacopsylla pyricola* Foerster) (Glenn et al. 1999; Puterka et al. 2000). Glenn et al. (1999) reported that hydrophobic mineral particle residues up to 3 mg $cm^{-2}$ leaf area did not change photosynthesis when applied at one time to apple, peach, or pear trees in a growth chamber with a uniform light intensity of 900 μmol $m^{-2}$ $s^{-1}$ PPF. In the field, hydrophobic mineral particles could be applied to plants at different growth stages. Light intensity and light quality will vary with time and within a plant canopy and mineral particle applications to leaves could alter dry weight distribution and reduce photosynthesis at low light intensity. Information on growth and photosynthetic response of plants treated with hydrophobic mineral particles will provide insight on potential horticultural effects of these particles. This research was designed to determine the dry weight partitioning and photosynthetic responses of bean plants to hydrophobic mineral particles under different light intensities in a greenhouse.

Two bean seeds were placed in 1.8-L plastic pots with Pro-Mix DX (Premier Horticulture, Red Hill, PA.), watered, and grown in a greenhouse. After germination, the less-vigorous seedling was removed from each pot. Plants were grown with natural sunlight at a 16-h photoperiod that was supplemented with high-pressure sodium light (average midday PPF of 560 μmol $m^{-2}$ $s^{-1}$). Plants were watered at least once each day and wetting of the shoots was avoided. Hydrophobic mineral particles (Kaolin, M96-018; Engelhard Corp., Iselin, NJ) were suspended in commercial-grade methanol (3 g 4 $mL^{-1}$) and diluted to 100 mL with water (Glenn et al. 1999). The suspension was continuously agitated by shaking and sprayed with a hand-held pump-action garden sprayer on to the shoot of a bean plant 1 wk after cotyledons had emerged. Plants were thoroughly wetted with the particle suspension to the point of drip.

One set of five plants was sprayed once each week for 8 wk with particle suspension and a second set of plants was sprayed once a week with dilute methanol only. A third set

**Abbreviations**: **PPF**, photosynthetic photon flux

**Table 1. Leaf number and area, dry weight, and shoot-to-root dry weight ratio of eight-week-old bean plants treated with hydrophobic mineral particles**

| Treatment | Leaf number | Leaf area ($cm^2$) | Leaf (g) | Pod (g) | Stem (g) | Root (g) | Shoot-to-root ratio |
|---|---|---|---|---|---|---|---|
| Particle | | | | | 0.8*a* | | .4*a* |
| Control | | | | | 0.9*a* | | ).9*b* |
| Methanol | | | | | 0.8*a* | | ).7*b* |

*a*, *b* Within each column, means followed by the same letter are not different based on the Bonferroni (Dunn) *t* test, $P \leq 0.05$.

**Table 2. Physiological characteristics of leaves of 8-wk-old bean plants treated with hydrophobic mineral particles**

| Treatment | Total chlorophyll (mg $cm^{-2}$ leaf) | Transpiration (mmol $m^{-2}$ $s^{-1}$) | Stomatal conductance (mmol $m^{-2}$ $s^{-1}$) | Leaf temperature (°C) | Photosynthetic rate (μmol $CO_2$ $m^{-2}$ $s^{-1}$) |
|---|---|---|---|---|---|
| Particle | 0.018*a* | 5.8*b* | 528*b* | !6.8*b* | 17.8*a* |
| Control | 0.012*b* | 6.5*a* | 608*ab* | !7.4*a* | 17.7*a* |
| Methanol | 0.014*ab* | 6.8*a* | 649*a* | !7.6*a* | 17.1*a* |

*a*, *b* Within each column, means followed by the same letter are not different based on the Bonferroni (Dunn) *t* test, $P \leq 0.05$. Transpiration, stomatal conductance, leaf temperature, and carbon assimilation are averaged across all photosythetic photon flux densities tested.

of untreated plants was used as controls. Photosynthesis, leaf chlorophyll, plant dry weight, leaf area, leaf temperature, and particle residues were measured the day after the final particle application (9 wk after seeding).

Photosynthesis, leaf temperature, transpiration, and stomatal conductance were measured at least six times on two leaves per plant (CIRAS-1; PP Systems, 619 Primrose St., Haverhill, MA). Photosynthesis was measured with different light intensities on control, particle-, and methanol-treated plants. Screens provided by PP Systems were used to study the effect of decreasing PPF on particle-treated plants. The light source was a halogen lamp attached to the adaxial side of the leaf and PPF was at 1548, 1002, 670, 319, 148, or 0 μmol $m^{-2}$ $s^{-1}$. At harvest, two leaves were cut from midpoint of the stem of each plant, leaf area measured (LI-COR, Lincoln, NE), and quickly extracted with 80% acetone saturated with $MgCO_3$ for chlorophyll measurement (Bruinsma 1963).

At the end of the experiment, 9 wk after seeding, two leaves from each plant were washed with 100 mL 5% (vol/vol) methanol and the rinsate was collected, evaporated, and the particle residue weighed to determine the quantity of particle that was on each plant. Each plant was separated into leaves, pod, and stem and the roots were carefully washed free of potting media. Leaf area was measured and plant parts were dried and weighed for each plant.

The experimental design was completely randomized, and the Bonferroni (Dunn) *t* test was used to separate means where significant treatment effects were found by analysis of variance. Effects of particle, methanol, and control treatments on dry weight distribution were evaluated in a one-way analysis. Leaf physiological characteristics were evaluated in a two-way analysis with light intensity and particle treatment as main effects. Because light intensity generally did not affect plant response, only particle treatment results are reported.

Bean pod dry weight decreased with both methanol and particle treatments (Table 1). Stem and leaf dry weights were not affected by particle treatments, but root dry weight of particle-treated plants was less than methanol-treated plants, indicating that particle films alter dry weight partitioning. Percent weight distribution was affected by treatments based on analysis of variance of arcsine-transformed data (data not shown). Percent weight distribution to roots was significantly less in particle-treated plants than in controls (18 and 23%, respectively). The shoot-to-root dry weight ratio was greater in particle-treated than in control plants (1.4 and 0.9, respectively). This observation is consistent with shaded plants having smaller roots, while maintaining or increasing vegetative growth of shoots (Kramer and Kozlowski 1979).

Plants respond to shade with increased ratio of chlorophyll to leaf weight and increased leaf area (Salisbury and Ross 1979). In the current experiment, total chlorophyll was greater in particle-treated plants than in control plants when chlorophyll was expressed on a leaf area basis (Table 2). Leaf area was not changed by any treatment (Table 1). Thus, particle treatments caused some shade-growth responses in bean plants by altering dry weight distribution and increasing chlorophyll content, but particle treatments did not increase leaf area. Previous research demonstrated greater reflectance of red than far red light by leaves treated with hydrophobic particles (Glenn et al. 1999). The shade-growth response of bean plants to particle treatment is consistent with plants growing with higher levels of far red than red light, such as plants growing in shade of a natural leaf canopy, and this may be mediated by phytochrome (Wareing and Phillips 1981).

Light intensities had only small effects on physiological characteristics of leaves and particle treatment effects were averaged across the six light intensities that were tested (Table 2). Across all PPF, transpiration, stomatal conductance, and leaf temperature were least in particle-treated plants (Table 2). This appeared incongruous because reduced transpiration can cause increased leaf temperature due to less evaporative cooling. However, in this experiment, it is likely that the particles reflected radiation, resulting in reduced heating of the leaf, as previously reported (Glenn et al. 1999). Photosynthetic rate was not affected by particle treatment (Table 2).

Bean plant photosynthesis was not reduced when particles were applied over 8 wk. In preliminary work, we found that eight particle applications made over 2 d resulted in particle residue concentrations of 7.04 mg particles $cm^{-2}$ leaf area and that these high residue concentrations reduced photosynthesis at light intensities below 148 µmol $m^{-2}$ $s^{-1}$. In the current experiment, some particles must have flaked off since particle residues were less than 3 mg $cm^{-2}$ leaf area. In field experiments with weekly particle applications, particle residues on apple leaves were less than 1 mg $cm^2$, but insect injury was reduced (Glenn, unpublished data). Thus, residues of hydrophobic mineral particles applied over time appear to be low enough not to inhibit photosynthesis. However, percent dry weight distribution to roots was less in particle-treated than control plants. These findings suggest that use of hydrophobic mineral particles for insect control may also affect plant development that can affect management decisions of horticultural crops.

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